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WITNESS my hand this  
Seventh day of January 2005

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*Patents Act 1990*

**PROVISIONAL SPECIFICATION**

**Invention Title: "WATER TREATMENT PROCESS"**

The invention is described in the following statement:

TITLE

## WATER TREATMENT PROCESS

FIELD OF INVENTION

The present invention generally relates to treatment of water and in particular  
5 wastewater including sewage.

BACKGROUND OF THE INVENTION

Water is an invaluable commodity and most regions of the world are faced  
with a limited and declining resource of fresh, consumable water due to diminishing  
water sources and tables, population growth, increasing industrialization, increasing  
10 agricultural activity and use of irrigation, and pollution of fresh water supplies.  
Therefore treatment of sewage, wastewater and ground water are becoming of  
increased importance worldwide and in areas where water is at a premium, such as  
highly populated areas and/or regions that have very little rainfall, water recycling is  
essential.

15 In the developed world water restrictions are frequently imposed on domestic  
users and commercial institutions by the government. In situations of water shortage  
the water supply may only be available for one to two hours a day and non-essential  
use of water for swimming pools, and watering plants, golf courses and parks may be  
banned. Even if sources of fresh water are readily available, water conservation and  
20 recycling or reclaiming are ecologically and environmentally preferred options.

Reclaimed waters can serve as an invaluable supplemental source of water,  
particularly for non-potable uses, such as industrial uses (building and cooling),  
washing, fire prevention, agricultural uses and water fountains and pools. One

suitable non-potable use for reclaimed water is the irrigation of crops, resorts, parks and golf courses and general landscaping, which constitutes approximately two thirds of total water demand. However, despite the wide range of uses for non-potable reclaimed water, water reclamation is rarely practiced. This may be due to a lack of 5 efficient and cost effective treatment processes and also to problems in accessing, distributing and transferring the treated reclaimed water to the sites of use.

A number of processes have heretofore been developed for treating sewage, wastewater and groundwater to obtain potable and non-potable water of varying quality. Such processes include the use of chemical treatment and physical treatment 10 systems. In a municipal sewage treatment plant system both the solid and liquid components of sewage are treated using the processes of clarification, aeration and disinfection. The main additives in the treatment process are oxygen or air for biodegradation of organic materials in the sewage and electrical power to operate pumps and compressors that deliver and mix the oxygen or air. The purified sewage 15 effluent is either recycled or discharged into the ocean or waterways and the solid sludge waste is disposed.

Raw sewage mining for water reclamation accesses raw sewage water from a municipal sewage pipe, treats and purifies the sewage water, returns the waste products to the municipal sewage pipe and the purified potable or non potable water 20 is recycled for human use. A useful raw sewage treatment process should provide consistent output of a specified quality, be relatively small in size, and must be cost effective to run.

Conventional treatment of sewage waters involve treating the wastewater

with an oxidizer, such as ozone or chlorine, solid separation in large open concrete vessels with long retention times and filtration of the wastewater using filtration or membrane microfiltration. The conventional systems have a large footprint (i.e. they require a large amount of space), a slow wastewater flow rate through the system and  
5 have to be constantly treated for inevitable breakouts of undesirable bacteria and microorganisms. In addition to pathogenic impurities, incoming wastewater can comprise hard and abrasive materials, such as stones, that can damage components of the treatment system and floatable materials, such as oils, greases and fibers that can block a physical treatment system. The conventional systems are also expensive to  
10 run and maintain and have limited contaminant removal ranges requiring specific equipment for specific contaminants. As a result, very few of the processes have been converted to practice and used for water reclamation on a large scale either because of unsatisfactory contaminant removal efficiency and/or high costs  
15 associated with the implementation of the process technology.

15 Dissolved Air Floatation (DAF) systems are typically end-of-line process systems that treat sewage that contains heavy particulate solids. DAF systems are typically large, not portable and are dependant on mechanical devices to remove sludge and foam. Such DAF systems comprise a chamber into which dissolved compressed air is passed through the wastewater to remove contaminants in a foam.  
20 The point at which the foam meets the water (foam water interface height) and therefore the foam wetness can not be varied in a DAF system which reduces the flexibility of the system in removing a wide variety of contaminants. DAF systems have a slow treatment rate, are not suitable for treating large volumes of water in

confined spaces and are expensive to operate and maintain.

US Patent Nos. 6,641,721 and 6,488,853 in the name of Mullerheim describes a wastewater reclamation process and apparatus that comprises a settleable solids separator and a gas floatation separation system. The wastewater can be obtained from a sewer. The solids separator, such as a vortex separator, separates settleable solids and floatable material from the wastewater prior to treatment of the wastewater by the gas floatation system which passes bubbles of gas through the wastewater producing a reusable liquid effluent and a froth component. Due to the solids separation and retention step this process could only be used as a batch process and thus could not be used as a continuous treatment process and consequently would not cope with high volumes of wastewater at high velocity.

In addition the process provides no procedures for adjusting foam height or wetness which is desirable for efficient contaminant removal using gas floatation technology.

It is therefore an object of the invention to provide a process that may alleviate the disadvantages of the prior art.

#### SUMMARY OF INVENTION

In a first aspect, the invention provides a water treatment process that comprises the steps of:

- 20 (a) adding a treatment agent to the influent water;
- (b) subsequently passing the water through a mixing zone;
- (c) adding a foaming agent to the water; and
- (d) passing the water through a foam fractionation zone to provide a

treated effluent,

where steps (a) and (b) may precede steps (c) and (d) or vice versa.

Prior to step (c) the water may be passed through a flocculation zone to remove any particles and colour from the water.

5 Preferably, the water remains in the flocculation zone for 2-15 minutes.

More preferably, the water remains in the flocculation zone 9 for 4-7 minutes.

Preferably, the pH of the water falls within the range of 7-8 pH.

10 In step (b) the mixing zone may comprise one or a plurality of mixing columns. More preferably, a 2 column system is used and the water is in contact with the treatment agent for approximately 2-6 minutes.

Preferably, the treatment agent is an oxidizing agent and/or an anti-microbial agent.

Suitably, step (a) can be repeated in between mixing zones.

15 Preferably, a foaming agent is added to the water prior to step (d).

Preferably, the rate of flow through the purification process is within the range 2000-3400 L/min/m<sup>2</sup>.

More preferably, the rate of flow is within the range 2600-2800 L/min/m<sup>2</sup>.

20 Preferably, the water is not retained within the foam fractionation for more than 200 sec.

After step (d) the treated effluent is discharged through a conduit into a collection tank. Preferably, the conduit comprises a valve which can provide resistance to the water flow through the conduit into the collection tank.

Suitably, the water may undergo a second pass through the treatment process.

Throughout this specification, "comprise", "comprises" and "comprising" are used inclusively rather than exclusively, will be understood to imply the inclusion of 5 a stated integer or group of integers but not the exclusion of any other integer or group of integers.

#### BRIEF DESCRIPTION OF THE DRAWINGS

Reference may now be made to preferred embodiments of the invention as shown in the attached drawings wherein:

- 10 Fig. 1: A schematic view of a water treatment system comprising oxidation, flocculating and foam fractionation zones.
- Fig. 2: A schematic view of a water treatment system showing an alternative method of water treatment.
- 15 Fig. 3: A schematic view of a water treatment system showing an alternative method of water treatment.
- Fig. 4: A view of the foam fractionating column assembly.
- Fig. 5: A view of the foam height adjustment valve.

#### DETAILED DESCRIPTION OF INVENTION

For the purposes of this invention, by "water" or "wastewater" is meant 20 any type of water found in sewage pipes or any water discharged from domestic, commercial, industrial, agricultural or aquaculture (fresh or marine) processes, or groundwater, bore water and reservoir water.

The water can contain contaminants such as, organic substances, such as

nitrates, proteins, fatty acids, polysaccharides and phospholipids, larger biological material, such as bacteria, viruses and algae, colloidal material, inorganic matter, leachates, metal ions, colour and particles.

The present invention provides a process for the treatment of water that  
5 comprises a foam fractionation system, also termed a particulates air separation system, and can be used for but is not limited to:

- (i) the removal of manganese or iron compounds;
- (ii) the removal of leachates (inclusive of metal ions and soil contaminants);
- 10 (iii) the production of class "A" or "B" irrigation water from wastewater obtained from raw sewage mining;
- (iv) the production of class "A" irrigation water from class "B" irrigation water (as defined in the South Australian Reclaimed Water Guidelines and the Queensland Guidelines for the safe use of recycled water);
- 15 (v) the removal or partial removal of nitrates, proteins, fatty acids, polysaccharides and phospholipids;
- (vi) the removal or partial removal of biological material inclusive of bacteria, viruses and algae;
- 20 (vii) the removal or partial removal of colloidal material; and
- (viii) the removal or partial removal of inorganic matter.

Fig. 1 shows a schematic drawing of water treatment system 1 which may be applied to water obtained from raw sewage mining from municipal sewage pipes.

The water may be obtained directly from municipal sewage pipelines (a process known as raw sewage mining), from domestic households, or from sewage treatment plants. If the water is obtained by raw sewage mining care is taken to ensure that only the water liquid stream is removed from the pipeline comprising a minimal amount of solids.

Water or raw sewage is supplied through conduit 2 by a raw water supply pump or other motive flow source 3. An optional pH sensor (not shown) may be located in conduit 2 at point 5 intermediate to pump 3 and flocculating column 10 to measure the pH of the water on a continuous basis using an automated controller or microprocessor.

If the pH of the water is greater than 8.0 an acid solution may be added to conduit 2. Preferably, the acid solution is a mineral acid, such as sulphuric or hydrochloric acid.

If the pH of the water is less than 7.0, alkali solution may be added to conduit 2. Preferably, the alkali solution is sodium hydroxide, sodium bicarbonate or potassium hydroxide or an alkaline earth species such as calcium hydroxide or lime.

The pH adjustment maintains the pH and/or carbonate hardness within the desired range for flocculation and foam fractionation and the pH can be adjusted to fall within any desired range.

In some cases a treatment agent, such as an oxidizing agent and/or an anti-microbial agent is added to the water at point 7 prior to passage through flocculation column 10. It will be appreciated that the oxidizing agent and/or anti-microbial agent may also be added to the water at point 25A discussed hereinafter. Suitable oxidising

agents may include chlorine, ozone, PROXITANE (3-5.4% peroxyacetic acid, 20-24% H<sub>2</sub>O<sub>2</sub>, 10-12% acetic acid and water), peroxyacetic acid, peracyclic acid, perchlorate, hydrogen peroxide and biocides. Suitable anti-microbial agents include biocides, iodine and disinfectants.

5       The water is passed into flocculating column 10 which may comprise static mixers or an agitator in the form of a rotatable paddle to agglomerate any solid particles in the water and to accelerate gravity separation of the solid particles.

·       Flocculants or thickening agents may be injected into conduit 2 at point 8.

10      Preferably, the thickening agents or flocculants may be selected from the group consisting of alum sulphate, polyaluminium chloride, ferric sulphate, ferric chloride and inorganic salt-polymer blends.

·       The flocculant mixes with the water in flocculant mixing zone 9 which preferably comprises a static mixer. The water then passes into the flocculating column reaction zone 11.

15      The water is transferred to foam fractionating column 16 through conduits 13 and 14.

20      Water transferred to column 16 via conduit 13 enters upper region 13B of column 13. Water transferred to column 16 via conduit 14 passes through pump or motive flow source 15, conduit 17, venturi 18, venturi conduit 18A and enters base 16B of column 16 through a gas diffuser or venturi nozzle 18C (not shown). Venturi 18, which can also be an injector or eductor, provides resistance to water flow thereby sucking air into the water. A foaming agent or surfactant may be used to increase the foaming ability of the water, the generation of consistent suitably sized

bubbles and to manipulate the foam wetness. Foaming agents usually comprise polymeric materials. Suitable foaming agents may include any anionic, cationic, amphoteric and non-ionic surfactant as described hereinafter, such as anionic sulfonate, sulphate surfactant, ether sulphates and AMPHOLYTE (amphoteric surfactant). The foaming agent may be added to the water prior to flocculation (at point 8) or added directly to fractionating column 16.

The water undergoes foam fractionation or particulates air separation (also known as protein skimming) in fractionating column 16. Fractionating column 16 (FIG. 4) comprises column body 16A, column base 16B, water inlet 13B, foam outlet 19, water outlet 20 and venturi nozzle 18C. The venturi system or an efficient, effective air diffuser draws in (through venturi gas inlet 18B) and diffuses a gas, such as air, ozone or gaseous chlorine with the water and generates a swarm of small bubbles which rise up the fractionating column through the water adsorbing dissolved and particulate contaminant molecules. The bubbles form stable foam at the top of the fractionating column and the foam comprising the contaminants is discharged through foam outlet 19. Fractionating column 16 will be described in detail in FIG 4 hereinafter.

The treated water effluent is discharged through column base 16B through water outlet 20 and is transferred to foam height adjustment valve 22 through conduit 21. Valve 22 (FIG. 5) provides resistance to water flow into storage tank 23 through conduit 24 and therefore controls the position of the foam/water interface and resultant foam height which alters the foam wetness, as described hereinafter. Preferably, storage tank 23 is open to the atmosphere.

The water is transferred from storage tank 23 to mixing columns 26 through conduit 24A and pump or motive flow source 25. Preferably, the water is retained within each mixing column for 1-3 minutes. An oxidising and/or anti-microbial agent is injected into conduit 24 at point 25A. An oxidizing and/or anti-microbial agent can also be injected at point 25B in between mixing columns 26. If there are a plurality of mixing columns oxidising and/or anti-microbial agents can be injected in between each column.

After oxidation/anti-microbial treatment the water is discharged through conduit 27 into collection tank 28. The purified water can then be transported to a site of use or if plant 1 is being used on site the purified water can be transferred directly from collection tank 28 to, for example, plants, grass or crops to be watered. The purified water can also be transferred into conduit 2 or fractionating column 16 for a second pass through the flocculating zone and/or the foam fractionation zone (not shown).

Preferably, the sludge and foam waste produced by the flocculating and foam fractionating steps respectively is discharged back into the municipal sewage pipeline or a drying bed or similar device. However, it will be appreciated that the sludge can be disposed of in a variety of ways.

Fig. 2 shows a schematic drawing of an alternative embodiment of water treatment system (1A) which may be applied to bore water or groundwater or to water obtained from raw sewage mining from municipal sewage pipes, treated sewage pipelines or reservoirs, abattoirs, diary factories and plant nurseries.

Water or raw sewage is supplied through conduit 2 by raw water supply pump or motive flow source 3 to mixing columns 30. Preferably, the water is retained within each oxidising column for 1-3 minutes. An oxidising and/or anti-microbial agent is injected into conduit 2 at point 29.

5 The water is discharged through conduit 31. A pH sensor may be located in conduit 31 at point 32 to measure the pH of the water on a continuous basis using an automated controller or microprocessor.

If the pH of the water is greater than 8.0 an acid solution may be added to conduit 31.

10 If the pH of the water is less than 7.0, alkali solution may be added to conduit 31.

A flocculating agent is injected into conduit 31 at point 33.

The water is passed into flocculating column 10 as described above.

15 The water is transferred to foam fractionating column 16 through conduits 13 and 14, as described above. A foaming agent can be added to the water prior to flocculation (at point 33) or added directly to fractionating column 16.

The water undergoes foam fractionation in fractionating column 16 and is passed through mixing columns 26 as described above.

20 Fig. 3 shows a schematic drawing of an alternative embodiment of water treatment system (1B) which may be applied to water comprising iron species contaminants.

Water is supplied through conduit 2 by raw water supply pump or motive flow source 3 to mixing columns 30. An oxidising and/or anti-microbial agent is injected

into conduit 2 at point 29. An oxidizing and/or anti-microbial agent may also be injected at point 35.

The water is discharged through conduit 31 and transferred to foam fractionating column 16 through conduits 13 and 14. Foam fractionation is carried out as described for FIGS. 1 and 2 and purified water is discharged through water outlet 20, foam height adjustment valve 22 and conduit 21 to storage tank 23.

One or a plurality of mixing columns can be used in the process. If the water comprises high levels of microbial contaminants multiple oxidising and/or anti-microbial agents and multiple mixing columns may be required. Preferably, steps (a) and (b) of the process are carried out after steps (c) and (d) when a large proportion of the contaminants have been removed by foam fractionation and therefore less chemicals are required.

Preferably, the water passed through the mixing columns from the bottom of the columns to the top which prevents air or gas from interfering with water flow.

The invention also includes within its scope a novel fractionation column assembly as shown in FIG. 4 and a novel valve assembly as shown in FIG. 5.

Fractionating column 16 has a number of distinctive zones (FIG. 4) including reaction zone 40, where the water and gas mix and react, foam formation zone 41, where the foam is allowed to stabilise and build, foam discharge zone 42, where the foam collects and the foam wetness or dryness is controlled, and separation zone 43, where the gas and water are allowed to separate. Venturi nozzle 18C is located in column base 16B and orientated so that the nozzle outlet faces upwards. Conduit

inlet nozzle 13C located at the top of column body 16A and below foaming zone 19A, is orientated so that the nozzle outlet faces downwards.

Preferably, foam formation zone 41, where the foam is allowed to stabilise and build, is non-agitated by the in-coming water through conduit inlet 13B and nozzle 5 13C.

Foam fractionation or particulates air separation predominantly removes surfactant contaminant molecules (molecules that have polar and non-polar ends). At the air-water interface of the bubbles the surfactant molecules orientate themselves so that the non-polar hydrophobic end of the surfactant molecules is in air and the polar hydrophilic end of the molecule is in water. As the bubbles rise to the top of the 10 fractionating column they remove the contaminants and settle at the top of the column as a foam.

Many organic substances can be removed by foam fractionation and larger biological material, such as algae, bacteria, flocs and viruses can also be removed. 15 Particles present in the water can also be removed. It is thought that biological material and particles become trapped in the film surrounding the air bubbles. Inorganic material can also be removed it can form some kind of a bond with organic matter in the water. For example, calcium carbonate and calcium phosphate complexes can collect organic matter in the water forming micro-flocs that can get 20 trapped in the film surrounding the air bubbles. Metal ions can also form ligands with organic molecules and glycoproteins have a high affinity for trace metals and therefore facilitate removal of metal ion species from water.

Efficient contaminant removal may be dependent on at least one of the following factors:

- (i) air to water ratio;
- (ii) column height;
- 5 (iii) air bubble diameter;
- (iv) air/water contact time;
- (v) air bubble flow rate;
- (vi) foaming agent;
- (vii) foam wetness;
- 10 (viii) downward water flow rate;
- (ix) foam stability; and
- (x) collision speed between the water and the rising gas.

Bubble size is an important factor. Smaller diameter bubbles result in a higher total surface area of the bubble swarm which facilitates more efficient adsorption of the water contaminants. Smaller bubbles also rise up the fractionating column more slowly, allowing more contact time with the water.

Preferably, the diameter of the bubbles falls within the range 0.5–3.0 mm.

Foam stability may also be an important factor and can be defined as the resistance to contaminant drainage from the foam without foam rupturing. The foam must be stable enough to remove from the fractionating column without leaching of the contaminant molecules into the water occurring. Preferably, the foam is removed immediately from the fractionating column.

Foam wetness (the amount of water contained with the foam) can be varied by varying the foam/water interface position in fractionating column 16. A wet foam which removes and retains more contaminants is preferred. Foam height adjustment valve 22 (FIG. 5) controls the position of the foam/water interface. Valve 22 comprises valve stem 50, valve body 51, handle 52, top projection 53, bearing plate 54, base projection 55, water inlet 56 and water outlet 57.

The resistance to water flow can be altered by adjusting the position of base projection 55 using handle 52. If the valve is partially closed by lowering projection 55, resistance to water flow through valve 22 from water inlet 56 to water outlet 57 is increased. The position of the foam/water interface rises up fractionating column 16 resulting in a shorter column of foam and therefore a wetter foam.

If the valve is opened by raising projection 55, resistance to water flow through valve 22 from water inlet 56 to water outlet 57 is decreased. The position of the foam/water interface falls down fractionating column 16 resulting in a longer column area of foam and therefore a dryer foam. If valve 22 is closed by lowering projection 55 water flow through the valve is prevented and water will exit water treatment system 1 through foam outlet 19. Closure of valve 22 can be used to flush fractionating column 16 to remove dirty foam from the inside of the column.

In one form, operation of valve assembly 22 may be carried out automatically and therefore the foam/water interface can be regulated automatically. This may be carried out by actuating the valve with a suitable drive motor, such as a DC drive motor, a pressure transducer and electronic logic control.

It will be appreciated by a person skilled in the art, that the use of different foaming agents may be required for waters comprising different chemical compositions. For example, cationic surfactants, such as aliphatic mono-, di- and polyamines, and 2-alkyl-1-(2-hydroxyethyl)-2-imidazolines, may be suitable for acidic waters. Anionic surfactants, such as carboxylates, sulphates, sulphonates and acylated protein hydrolysates, may be suitable for alkaline wastewaters. Non-ionic surfactants, such as carboxylic acid esters and amides, and polyalkylene oxide block copolymers, have no discrete charge when dissolved in aqueous media and may be suitable for acidic, neutral and alkaline waters. Amphoteric surfactants, such as imidazolinium derivatives, comprise both an acidic and a basic hydrophilic group and may be suitable for acidic, neutral and alkaline waters.

Foam fractionating column 16 has been specifically designed for this water process to have a predicted downward water flow rate (and therefore velocity).

Preferably, the introduced diffused gas to water ratio falls within the range 15 of 20% to 50% of the water flow. Foam outlet 19 facilitates the immediate removal of the produced foam from the stream.

Preferably, foam outlet 19 has a concentric cone structure facilitating foam discharge out of fractionating column 16.

Preferably, the rate of flow of water through the column falls within the 20 range 2000  $\ell /min/m^2$  (0.034 m/sec) to 3400  $\ell /min/m^2$  (0.057 m/sec).

More preferably, the rate of flow is 2700  $\ell /min/m^2$  (0.045 m/sec).

Preferably, water is not retained within column body 16A for more than 30 seconds.

Preferably, base 16B of the column does not have a rate of water flow greater than 1200 l/min/m<sup>2</sup> (0.02 m/sec).

Preferably, the length of column body 16A is 180% greater in length than column base 16B.

5 More preferably, the length of column body 16A is 190% greater in length than base 16B.

Preferably, the diameter of base 16B is 60% larger than the diameter of column body 16A.

10 Preferably, the total retention time of the water in column 16 falls within the range 75-200 sec for all columns with a diameter of less than 2000 mm.

Preferably, the interconnection between the stepped base 16B and the body column 16A comprises a 60 degree concentric cone.

15 Preferably, the distance of foam formation zone 19A from water inlet 13B falls within the range 200-500 mm.

Preferably, the inlet nozzle 13C is orientated downwards so water is discharged down column 16.

20 Preferably, the introduced gas through venturi conduit 18A has a volume greater than 20% of the total volume of water passing through outlet conduit 21.

More preferably, the volume of gas introduced through venturi conduit 18A falls within the range of 25-50% of the total volume of water passing through outlet conduit 21.

Preferably, foam outlet 19 has an area which is 1.5-3.5 times greater in area than inlet 13B.

More preferably, foam outlet 19 has an area twice the size of the area of inlet 13B.

Preferably, foam collection zone 19A comprises a concentric cone located at the top of fractionating column 16.

5 Preferably, the velocity of water passing through water outlet 20 is less than 0.5 m/sec.

Preferably, water outlet 20 is located in base 16B and has a sparge arrangement 45 whereby the water access ports face downwards towards the floor of base 16B to prevent air bubbles accessing water outlet 20.

10 The power system controlling wastewater treatment systems 1, 1A and 1B may be automated to facilitate precise control and to provide flexibility in controlling the foam fractionation process.

15 Preferably, water treatment systems 1, 1A and 1B are designed to be compact and portable to facilitate transport to and use in developed areas and areas of confined space.

Preferably, the systems can be mounted on ground engaging wheels or a skid. There also may be provided a generator (electrical or solar) for providing electrical power to the system.

20 Modifications may be made to the water treatment process. The order of the treatment steps may be modified subject to the nature or composition of the water.

Additional or modified process steps may be required when treating water comprising other contaminants, to contend with differing chemical properties of the contaminants. Different flocculating, foaming and oxidising agents may be utilised.

Suitable pre-treatment steps may be required for effective contaminant removal, such as solid separation using a hydrocyclone or centrifuge. Post-treatment steps such as ultraviolet treatment may also be carried out.

So that the invention may be more readily understood and put into practical effect, the skilled person is referred to the following non-limiting examples.

#### EXAMPLES

##### **Example 1**

Raw water (bore water) contained 14 mg/L of iron, had a pH of 6.3 and conductivity of 1.7 mS/cm

Water treatment system 1B as shown in FIG. 3 was used. The water was oxidised with sodium hypochlorite for 2 minutes before passing through fractionating column 16. A non-ionic foaming agent was used. The rate of flow through the water purification system was 2000 L/hr.

##### **Results**

The foam wetness was firm. The oxidized iron was readily visible in the discharged foam waste. The pH of the purified water was 6.4 and conductivity was unchanged at 1.7 mS/cm. The amount of iron remaining in the purified water was 0.18 mg/L.

The water loss or wastage was approximately 0.1% of the total volume of water passing through the system.

The advantages of the water treatment system of this invention are as follows:

- (i) the process allows the rapid treatment of large volumes of water and can treat effectively 2000-3400 L/min/m<sup>2</sup>;

- (ii) the system carries out a continuous and instant separation and removal of unwanted material from the water;
- (iii) the system can be automated, compact and portable;
- 5 (iv) the system has a small foot print in comparison to conventional water treatment systems rendering it very practical for use in highly developed areas where space is scarce and land is at a premium;
- 10 (v) the system comprises no media, membranes, screens, barriers or the like which require constant cleaning, replacement and treatment for undesirable bacteria;
- (vi) the system comprises no moving parts and therefore is less complex, easy to clean and easy to operate;
- 15 (vii) the process can perform effectively the simultaneous removal of multiple contaminants;
- (viii) water wastage is negligible and can be as little as 0.05% of the total volume of water passing through the system; and
- (ix) the process is cost effective, the costs of running the system being a fraction of the cost of running conventional systems.

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DATED seventeenth day of December 2003

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